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TURBULENCE EFFECTS IN A FOLDED PATH

by

Song Zhengfang

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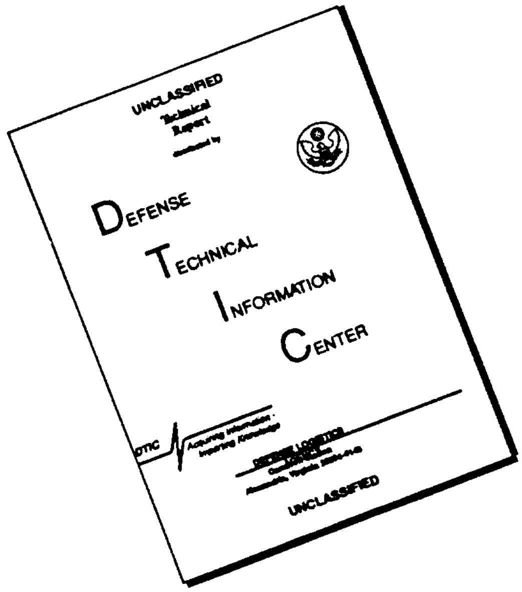

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By: Song Zhengfang

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TURBULENCE EFFECTS IN A FOLDED PATH

Song Zhengfang

I. INTRODUCTION

In laser applications to such things as range finding, tracking, guidance, pollution monitoring, autoadaptive technologies, and so on, sending and receiving are positioned on the same end. On the other end is installed a certain type of reflector body. Beams go back and forth in a turbulent flow path. This type of light path is generally called a folded path.

Moreover, we call light paths of straight line propagation in single directions direct light paths. Early in the 1970's, it had already been discovered that turbulent flow influences on folded light paths were very greatly different compared to direct light paths [1], thereby promoting theoretical and experimental research related to reflection field turbulent flow effect problems. Early theoretical work had made use of the concept of "back query scattering amplification phenomena"[2,3] in order to describe characteristic phenomena associated with folded light paths. Subsequent in depth research discovered that amplification effects were not the only phenomena. Under certain types of conditions, there also exist what are called "self-compensating effects"[4]. Up to the present time, probes have already been done with regard to the characteristics associated with multiple types of turbulence effects in reflection fields in order to facilitate--on a foundation of adequate understanding--the adoption of appropriate measures so as to improve the sensitivity of optical systems as well as reduce the influences of turbulence. This article introduces research results associated with such areas as intensity fluctuations, beam spread, spot quiver, as well as light path length fluctuations, and so on. Limited by the scope of the article, stress is laid on elucidating basic results--simplifying lengthy derivations.

II. INTENSITY FLUCTUATIONS

1. Statistical Intensity Moments /2

Making use of the principles of reciprocity, from wave field complex amplitudes associated with planar target reflections, it is possible to write [5]

$$U_r(x_0,\rho) = \int d^2t\,d^2r\,u_0(t)K(r)G(x,x_0;r,\tau;\rho,t) \qquad (1)$$

In the equation, uo(t) is complex amplitudes associated with sending aperture locations. Source points and observation points are located, in all cases, within plane x' = xo. k(r) is reflection coefficients associated with reflection devices within the plane x' = x. G(x,xo; r,τ; ρ,t) is called a local Green function. It is a product of direct wave and reflected wave Green functions. ρ and r are, respectively, lateral vector locations associated with the interiors of plane x' = xo and x' = x. Local Green functions satisfy the equation below:

$$\left\{ -2ik\frac{\partial}{\partial x} + (\Delta_{\rho_1}{}' + \Delta_{t}{}') + k^2[\varepsilon_1(x',t') + \varepsilon_1(x',\rho')] \right\} G = 0 \tag{2}$$

Boundary conditions are

$$G(x,x;r,\tau;\rho',t') = \delta(r-\rho')\delta(\tau-t') \tag{3}$$

In equation (2), ε1(x',z') is the dielectric constant fluctuation field. Δρ' is lateral Laplace operator.

On the basis of equation (1), it is possible to write the 2n order reflection field coherence function

$$\Gamma_{2n,r}(x_0,\rho_{2n}) = \int d^2t_{2n} \int d^2r_{2n} u_{2n}(x_0,t_{2n}) K_{2n}(r_{2n}) \cdot \langle G_{2n}(x,x_0;r_{2n},\tau_{2n};\rho_{2n},t_{2n}) \rangle \tag{4}$$

In the equation,

$$G_{2s}(x,x_0;r_{2s},\tau_{2s};\rho_{2s},t_{2s}) = \prod_{j=1}^{n} G(x,x_0;r_{2j-1},\tau_{2j-1};\rho_{2j-1},t_{2j-1})$$

$$\cdot G^*(x,x_0;r_{2j},\tau_{2j};\rho_{2j},t_{2j})K_{2s}(r_{2s}) = \prod_{j=1}^{n} u\,(t_{2j-1})u^*(t_{2j}) \tag{5}$$

In actuality, what is of comparatively great significance is the second order mutual coherence function Γ2r (xo,ρ2) normalized strength fluctuation variance σI,2r(xo,R) and spacial correlation coefficient bI,r(xo,ρ1ρ2). The definitions of σI, 2s and bI,r)

are

$$\sigma_{I,r}^2(x_0,R) = B_{I,r}(x_0;R,R)/\Gamma_{2,r}^2(x_0,R,R) \tag{6}$$

$$b_{I,r}(x_0\rho_1,\rho_2) = B_{I,r}(x_0,\rho_1,\rho_2)/\prod_{i=1,2} B_{I,r}^{1/2}(x_0,\rho_i,\rho_i) \tag{7}$$

In equations,

$$B_{I,r}(x_0,\rho_1,\rho_2) = \Gamma_{4,r}(x_0,\rho_1,\rho_1,\rho_2,\rho_2) - \Gamma_{2,r}(x_0,\rho_1,\rho_2)L_{2,r}(x_0,\rho_1\rho_2) \tag{8}$$

is called a spacial correlation function. These functions involve local Green function second order moments (G2) and fourth order moments (G4). Aksenov and others [5] have made detailed

discussions--under certain conditions--of planar wave and spherical wave second order mutual coherence functions, degrees of spacial coherence, as well as coherence lengths in cases associated with point reflectors, planar reflectors, and diffuse reflection objects. The author is not prepared here to quote in detail. Only some simple discussion will be made of comparatively significant results.

Intensity amplification coefficients are defined as

$$G_I(R) = \Gamma_{2,r}(R,0)/\Gamma_{2,r}^{0}(R,0) \tag{9}$$

In equations, Γ2,ro(R,O) is the intensity of light waves in a vacuum. Calculation results clearly show that--under conditions of weak turbulence and in regard to diffuse reflectors--when Ωr --> ∞, planar wave amplification coefficient GI(illegible)(R) --> 1 . When ΩI --> 1, planar wave GI (O) = 1 + 0.31Ds (lF) . Spherical wave GI (O) = 1 + 0.45Ds (lF). In this, Ωr = kar2/L. ar is effective radius of reflector bodies. Ds(lF) is a normalized parameter (=1.092Cn2K2L1F5/3). lF = (L/k)1/2. As a result, it is possible to see that, when option is made for the use of reflection associated with diffuse reflection objects of limited dimensions, amplification coefficients are, in all cases, larger than 1. Under conditions of strong turbulence, there are also relationships similar to the ones discussed above. Besides this, spherical wave reflection amplification effects not only exist in point reflector situations. They also exist in planar reflector situations where dimensions exceed first Fresnel band radii. Amplification coefficients associated with these two types of situations are the same. /3

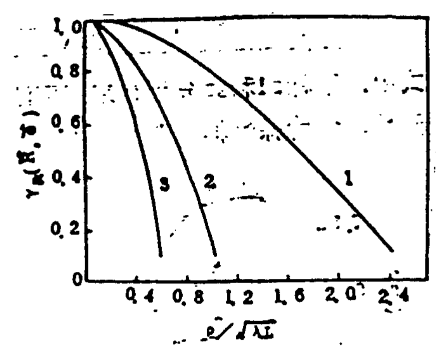


Fig.1 Relationships Between Degrees of Spacial Coherence and Relative Apertures

Key: 2. Direct Light Path

Fig.1 gives relationships between degrees of spacial coherence γr (R,R) and relative apertures $(\rho/\sqrt{\lambda L})$. Coherence characteristics associated with point reflector situations (Curve 1) will be much larger than values associated with direct light paths (Curve 2). However, coherence characteristics associated with planar reflector situations (Curve 3) are, by contrast, smaller values than those associated with direct light paths. Calculation results with regard to spherical waves clearly show, by contrast, that coherence characteristics associated with point reflector situations and direct light paths are the same. Coherence characteristics associated with remaining reflection light paths are, in all cases, smaller than direct light paths.

During strong turbulence, values associated with coherence length for spherical waves on planar reflection light paths are the same as those transmitted forward distances 2L on direct light paths. Coherence lengths associated with spherical waves in point reflector situations are equal to values during backward transmission distances L. During planar reflection, planar wave coherence lengths are equal to those during direct 2L prorogations. In point reflector cases, by contrast, they are equal to values associated with spherical surface waves during backward transmissions L.

2. Intensity Fluctuation Variances

Table 1 compiles expressions for normalized intensity fluctuation variances in different situations [5]. From among them, it is possible to know that, when fluctuations are weak, intensity fluctuation amplification effects associated with reflection field spherical wave surfaces will be larger than those associated with planar waves. If one takes intensity fluctuation amplification coefficients and defines them as the ratio of reflection field intensity variance with respect to direct light path (2L) intensity variances (infinite planar reflector case) or the ratio of the sum of reflector wave intensity variances versus direct waves (point reflector devices), it is then possible to discover that spherical wave amplification coefficients approach 2. Planar wave amplification coefficients are approximately 1.5. As far as diffuse reflection paths are concerned, amplification effects also exist. However, there is a relationship to the dimensions of diffuse reflecting bodies. When diffuse reflecting body dimensions enlarge, intensity fluctuations will be reduced. In limit situations ($\Omega r \rightarrow \infty$), σI, r2 --> 1, that is, intensity fluctuations only depend on random phase changes produced by target surface roughness.

During intensity fluctuations, due to the fact that, as far as scintillation saturation effects are concerned--no matter whether use is made of point reflectors or infinite planar reflector reflection--$\sigma I,r2$ associated with planar waves and spherical surface waves will tend toward saturation in the same way as on direct light paths. With regard to this type of situation, it also appears on diffuse reflection light paths.

Under conditions where turbulent flow intensity, light path length, and wave lengths are the same, during weak turbulent flows, intensity fluctuation variances associated with planar waves on infinite planar reflectors are the largest. Values associated with spherical surface waves on point reflection light paths are smallest. During strong turbulent flows, this is just the reverse. In situations where diffusion body dimensions are finite ($\Omega r \sim 1$), there are also situations similar to those discussed above.

3. Time Frequency Spectra

On the basis of spacial covariances associated with transmission on folded light paths with planar reflectors for planar waves and spherical waves, Smith and Pries [6] introduced Taylor freezing hypotheses in order to laterally intersect products of wind velocity v and time T to display spacial distance ρ. In conjunction with this, adoption was made of Fourier transforms associated with spacial covariances, respectively solving for frequency spectra associated with planar waves and spherical waves:

$$W_{P1}(f) = 64\pi^2 k^2 \int_0^L dz \int_{\omega/V}^{\infty} dK K \Phi_n(K)[(Kv)^2 - \omega^2] \sin^2\left(\frac{K^2 L}{k}\right) \cdot \cos^2\left[\frac{K^2(L-z)}{2k}\right] \tag{10}$$

/4

$$W_{sp}(f) = 64\pi^2 k^2 \int_0 dz \int_{\omega/V} dK K \Phi_n(K)[(Kv)^2 - \omega^2] \sin^2\left[\frac{K^2 z(2L-z)}{4kL}\right] \cdot \cos^2\left[\frac{\rho_1(L-z)\omega}{2Lv}\right] \tag{11}$$

In equations, subscripts pl and sp stand respectively for planar waves and spherical waves. $\omega = 2\pi f$. K is the spacial wave number. (Illegible)nK is the refractive index fluctuation spectral function. $\rho 1$ is the distance of detectors from the centers of beams.

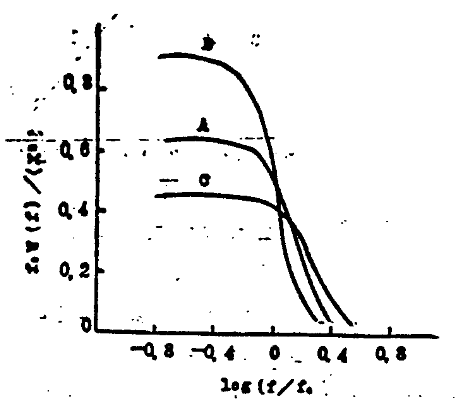


Fig.2 Planar Wave Logarithmic Amplitude Fluctuation Normalized Frequency Spectra. A. Direct Light Path (2L) B. Folded Light Path C. Direct Light Path (L)

In expressions (10) and (11), it is only necessary to take sin2 [K2 (t-z)/2k) to substitute for 4sin2 (K2L/2k)cos2 [K2 (L-z)/2k] and let $\rho 1 = 0$ and it is then possible to obtain corresponding frequency spectra on direct light paths. After precisely determining refractive index spectral functions (for example, opting for the use of Kolmogorov spectra), it is then possible to solve for the actual forms of frequency spectra. Calculations clearly show that reflection field scintillation energies appear comparatively frequently at low frequency ends (refer to Fig.2). This is because effective turbulent flow scales leading to intensity fluctuations on reflection paths are larger than for direct light paths.

Calculation results with regard to spherical surface wave frequency spectra point out that, the closer observation points are to the center of beams, the larger are high frequency fluctuations. Therefore, when making use of spherical surface wave scintillation remote sensing of lateral wind speeds, it is best to offset from the centers of light axes in order to reduce certain undesired variations in signals.

III. BEAM SPREAD

On the basis of reflection field second order moments, after going through a certain processing--with regard to situations in which Gaussian beams are formed with (illegible)o (x) = uo (O)exp(-x2/2a2) (in them a-2 = a-2 + ik/F) in effective amplitude reflection coefficients associated with angular reflectors also possessing Gaussian distribution ($r(\rho)$=roexp(-p2/2ar2)) and planar reflector reflection coefficient $r(\rho)$=1--we derive the expression associated with reflection field mean square radii [7]

$$\langle \rho_L^2 \rangle_{\bullet} = \frac{8L^4}{k^4}\left\{\left[\rho_0^{-2} + \frac{dk^2}{4L^2(d^2+c^2-\rho_0^{-4})}\right]^2 + \left[\frac{ck^2}{4L(d^2+c^2-\rho_0^{-4})}\right]^2 - \left[\rho_0^{-2} + \frac{k^2\rho_0^{-2}}{4L^2(d^2+c^2-\rho_0^{-4})}\right]^2\right\}\left(\frac{d-\rho_0^{-2}}{d^2+c^2-\rho_0^{-4}}\right)^{-1}$$

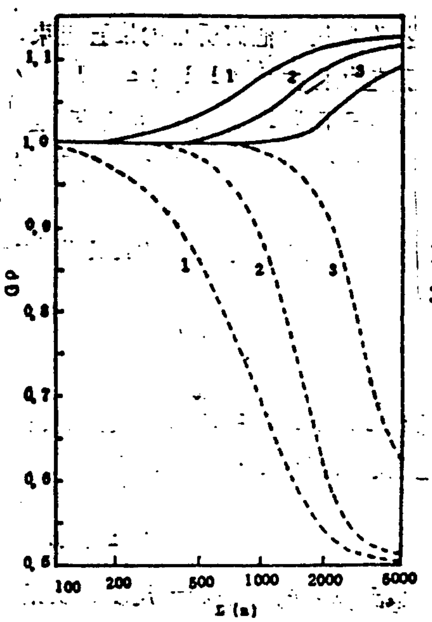
(planar reflector)

(12)

$$\langle \rho_L^2 \rangle_a = \frac{8L^4}{k^4}\left\{\left[\rho_a^{-2} + \frac{dk^2}{4L^2(d^2+c^2-\rho_a^{-4})}\right]^2 + \left[\frac{k}{L} + \frac{ck^2}{4L^2(d^2+c^2-\rho_0^{-4})}\right]^2 - \left[\rho_0^{-2} + \frac{k^2\rho_0^{-2}}{4L^2(d^2+c^2-\rho_0^{-4})}\right]^2\right\}\left(\frac{2L^2}{k^2a_1^2} + \frac{d-\rho_0^{-2}}{d^2+c^2-\rho_0^{-4}}\right)^{-1}$$

(angular reflector)

(13)



1. $C_n^2 = 10^{-12} m^{-2/3}$, 2. $C_n^2 = 10^{-13} m^{-2/3}$, 3. $C_n^2 = 10^{-14} m^{-2/3}$

Fig.3 Beam Spread Amplifications in Different Cases (1) Planar Reflector (2) Angular Reflector

In equations, $c = \frac{k}{2F} - \frac{k}{2L}$, $d = \frac{1}{2a^2} + \rho_0^{-2}$, , ρo is spherical wave coherence length (=(0.546cn2K2L)-3/5). /5

Reflection field beam spread amplification coefficient Gρ is

$$G\rho = (\langle \rho_L^2 \rangle_{s,a})^{1/2} / (\langle \rho_{2L}^2 \rangle_d)^{1/2} \quad (14)$$

In equations, (<ρ2L2>d)1/2 are effective radii on direct light paths:

$$\langle \rho_{2L}^2 \rangle_d = a^2[(1+2L/F)^2 + 4(1+4a^2\rho_0^{-2})L^2/k^2a^4] \quad (15)$$

Fig.3 gives calculation results associated with focal beams (F=2L) for cases with different turbulence intensities C(illegible)2. From the Fig. in question, it is possible to know

that planar reflector state beam spread amplification coefficients Gρ>1. In locations at close distances, amplification coefficients are comparatively small. When distances are relatively long, Gρ tends toward saturation. However, speaking in general terms, differences between planar reflector reflections and linear propagation are not great (Gρ ≤ 1). The strength or weakness of the effects in question is related to various types of parameters. However, the primary ones are transmission distance and turbulence intensity. In optimum situations, Gρ --> 0.5 .

IV. SPOT QUIVER

Starting out from parabolic wave field equations, application is made of Maerkefu (phonetic) approximations. The general expression associated with our solving for reflection field drift angle θ fluctuation covariances σθ,r2 [8] is

$$\sigma_{\theta,r}^2=\sigma_\theta^2(L_f)+\sigma_\theta^2(L_b)\pm 2\sigma_{\theta,fb}^2 \tag{16}$$

In the equation, Lf and Lb refer, respectively, to forward and back transmission distances. σθ,fb2 are drift angle fluctuation variances led to by interference superpositions between incident light and reflected light. In planar reflector situations, σθ,fb2 are adopted with positive signs. In angular reflector situations, negative signs are selected. Expressions associated with these three components are

$$\sigma_\theta^2(L_f)=\int\int(\rho_1,\rho_2)\langle I(\rho_1)I(\rho_2)\rangle d\rho_1 d\rho/\left(\int I(\rho)d\rho\right)^2L^2 \tag{17}$$

$$\sigma_\theta^2(L_b)=\frac{2\pi L}{P_e}\int_0^1(1-\xi)^2d\xi\int d^2R_1d^2R_2d^2K\Phi_n(K)K^2\langle I(1-\xi,R)\cdot I(1-\xi,R_2)\rangle\exp[jk\cdot(R_1-R_2)] \tag{18}$$

$$\sigma_{\theta,fb}^2=\frac{2\pi L}{P_e}\int_0^1\xi(1-\xi)d\xi\int d^2R_1d^2R_2d^2K\Phi_n(K)K^2\langle I(\xi,R)\cdot I(\xi,R_2)\rangle\exp[ik\cdot(R_1-R_2)] \tag{19}$$

Obviously, $\sigma_{\theta,r}^2\neq\sigma_{\theta,d}^2(2L)$. We now consider properties associated with reflection field beam drift angles in special cases.

In weak fluctuation areas, it is possible to rationally believe that $I(\xi,R)\simeq I(0,R)\simeq I_0$. Because of this, one obtains

(planar reflector)

$$\sigma_{\theta,r}^2=\begin{cases}3/2\sigma_{\theta,d}^2(2L)\\ 1/2\sigma_{\theta,d}^2(2L)\end{cases} \quad (20)$$

(angular reflector)

/6

We look next at amplification effects in planar reflector situations ($G\theta=1.5$) and self-compensating effects ($G\theta=0.5$) associated with angular reflector situations. $\sigma\theta$,d2 calculation formulae have already been discussed in detail in references [9,10]. We will not give unnecessary details again here.

Kopileoich and Sochilin [11]--using gentle microperturbation approximations--also obtained results in line with ours. However, in derivations, we certainly were not limited to the collimation light beams which they used. Therefore, equation (20) should also be appropriate for use in cases of focused beams.

In regions of strong fluctuation, due to the fact that (illegible) <I1I2>≈<I1> <I2> Γ22 ≈ <I1> <I2>--in accordance with analyses of reflected light mutual coherence functions $|\Gamma_{2}|^2 \approx \langle I_1 \rangle \langle I_2 \rangle$ by Krupnik and others [12]--when beam radii a >> ρo (L), <Ir(L)> ≈ <Id (2L)>. Therefore, one has $\sigma\theta$,r2(L) ≈ $\sigma\theta$,d2(2L). This explains the disappearance ($G\theta$-->1) of special functions associated with reflection fields along with increases in transmission distances or increases in turbulent flow intensity.

Similar handling methods are also appropriate for use in discussing problems associated with reflection field beams arriving at angle α fluctuations. In weak fluctuation areas, with respect to interference terms, we obtain

(planar reflector)

$$\sigma_{\alpha,r}^2=\begin{cases}2\sigma_{\alpha}^2(2L)\\ 0\end{cases} \quad (21)$$

(angular reflector)

The results discussed above and the results obtained by Krupnik et al [12] using other methods are completely in agreement.

In strong fluctuation areas, $\sigma\alpha$,r2 (L) ≈ $\sigma\alpha$,d2 (2L), that is, reflection fields reaching angular fluctuations are consistent with periods when direct propagation is 2L.

V. LIGHT PATH LENGTH FLUCTUATIONS

Consideration of range finding problems is connected with large scales. We make use of geometrical optical approximations in order to handle them [13]. In a similar way to spot quiver,

planar reflector reflection field light path fluctuation variances <ΔL2r>m can be expressed as

$$\langle \Delta L_r^2 \rangle_m = \langle \Delta L_f^2 \rangle_m + \langle \Delta L_b^2 \rangle_m + \langle \Delta L_{fb} \rangle_m \tag{22}$$

As far as intermediate forms are concerned,

$$\langle \Delta L_f^2 \rangle_m = \int_0^L dx_1 \int_0^{X_1} dx_2 \langle n_1(x_1,\rho_1) n_1(x_2,\rho_2) \rangle \tag{23}$$

$$\langle \Delta L_b^2 \rangle_m = \int_0^L dx_1 \int_0^{X_1} dx_2 \langle n_1(L-x_1,\rho_1) n_1(L-x_2,\rho_2) \rangle \tag{24}$$

$$\langle \Delta L_{fb}^2 \rangle_m = 2\int_0^L dx_1 \int_0^L dx_2 \langle n_1(x_1,\rho_1) n_1(L-x_2,\rho_2) \rangle \tag{25}$$

It is assumed that index of refraction fluctuation n1 (X,ρ) is a statistically uniform Gaussian field. In conjunction with this, application is made of Van Karman turbulence spectra. After operations, one obtains

$$\langle \Delta L_r^2 \rangle_m = 6.254 C_n^2(0) L_e L_0^{5/3} [1 + 0.9943 (\rho/L_0)^{5/6} K_{-5/6}(\rho/L_0)] \tag{26}$$

In equations, Cn2 (O) are observation position turbulence flow intensities. Lo is turbulent flow outer dimensions. K-5/6 (ρ/Lo) is an imaginary argument Hanke (phonetic) function. L(illegible) is equivalent distance:

$$L_e = \int_0^L C_n^2(x) dx / C_n^2(0) \tag{27}$$

If turbulent flow is uniform, then, L(illegible) is equal to light path length L.

Compared to light path fluctuation variances associated with direct propagation of distances 2L, it is possible to know that amplification coefficients associated with reflection field light path fluctuations

$$G_{L,fb} = 1 + 0.9943 (\rho/L_0)^{5/6} K_{-5/6}(\rho/L_0) \tag{28}$$

Fig.4 describes changes in amplification coefficients as functions of relative distances ρ/Lo. From Fig.'s, it is possible to see that when ρ/Lo << 1 GL=2. When ρ/Lo >> 1, GL --> 1. In general situations, ρ ≤ 10cm and Lo ≈ 1m. Therefore, amplification effects associated with planar reflected light paths always exist.

During the process of deriving formula (26), there was

certainly no limitation of beam forms. As a result, the conclusions described above are appropriate for use with beams of any configuration. /7

When making use of angular reflectors, with regard to single mode Gaussian beams applying expanded Huygens-Fresnel principles, we solve for

$$\langle \Delta L_r^2 \rangle_c = 3.127 C_n^2(0) L_c L_0^{5/3} [1 + T^2 + 1.989 T (\rho/L_0)^{5/6} K_{-5/6}(\rho/L_0)] \qquad (29)$$

In equations,

$$T = (4+\gamma^2)(1+\Omega\Omega_r+\nu^2)/(4+\gamma^2+\Omega\gamma)[(1+\Omega\Omega_r)^2+\nu^2] \qquad (30)$$

ϕ is beam angle of divergence. The meanings of other symbols are as before. In general situations, the condition is satisfied that $\rho \ll L_0$. Expression (29) can be simplified to be

$$\langle \Delta L_r^2 \rangle_c = 3.127 C_n^2(0) L_c L_0^{5/3} (1+T)^2 \qquad (31)$$

As a result, light path fluctuation amplification coefficients in angular reflector situations

$$G_{L,c} = \frac{1}{2}(1+T)^2 \qquad (32)$$

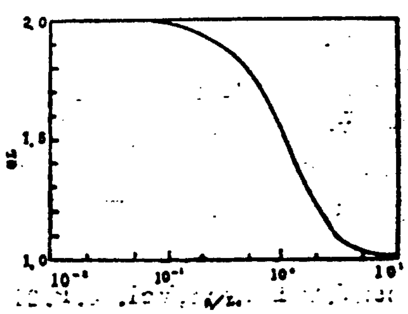
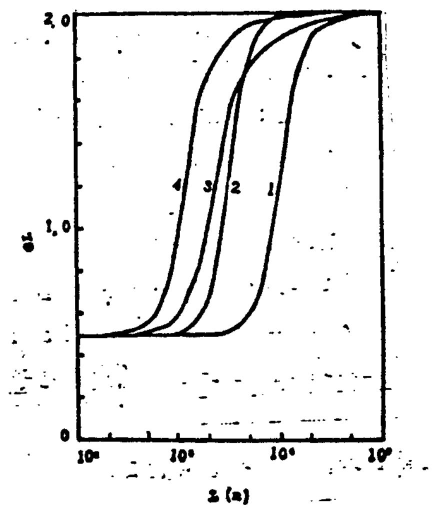


Fig.4 Changes in Amplification Coefficients as a Function of Relative Intervals

Fig.5 gives changes in amplification coefficients under different conditions as functions of distance. Amplification coefficients as a whole are inserted between 0.5 ~ 2. When distances are short, GL,c --> 1/2. This is nothing else than self-compensating effects under proximate field conditions. When distances are long, GL, c --> 2, it is then appropriate to make use of them in planar reflector situations. This is because, when distances are

long, diffraction effects play a dominant role. The special functions of angular reflectors disappear. At intermediate distances, amplification coefficients depend on wave length, transmission and reflection apertures as well as beam angles of divergence. Comparing the four curves in Fig.5, it is possible to know that, at the same distances, amplification (or self-compensation) effects are comparatively obvious in situations



1. $\lambda=0.63\mu m, a=a_r=0.1m; \phi=10^{-4}rad$; 2. $\phi=10^{-3}rad$,其余同1; 3. $\lambda=10.6\mu m$;其余同1; 4. $a=0.025m$,其余同1. (1) (1) (1)

Fig.5 Relationships of Amplification Coefficients as Functions of Distances (1) Others Same as 1

where wave lengths are long, apertures are small, and angles of divergence are large. The facts described above mean that--making use of short wave lengths, small divergences, as well as large reception and transmission apertures--it is possible to reduce turbulent flow effects. This conclusion can be explained like this. The smaller distances are, or the shorter wave lengths are, the smaller related turbulent flow dimensions then are. The smaller divergence angles are, it is equivalent to enlarging reception and transmission apertures. Moreover, the larger apertures are, the more numerous uncorrelated elements which are included then are. Adopting average results, there is then a correspondence with relatively small light path fluctuations.

VI. DISCUSSION

/8

Above, we have considered the influences of reflection field turbulent flow influences on such things as beam intensities, spreads, drifts, as well as light path fluctuations, and so on. Generally speaking, amplification phenomena exist on light paths which make use of planar reflectors. Self-compensation effects

exist on light paths making use of angular reflectors. This is because there exist mutually overlapping regions of incident light beams and reflected light beams. Light waves produce interference. In cases of planar reflector reflection, this then leads to a strengthening of turbulent flow influences. This is an amplification phenomenon. In angular reflector situations, due to them possessing the characteristic of being able to make reflected light return along its original direction of incidence, geometrical divergence drops, and phase fluctuations are reduced, thereby playing a compensating role with regard to spot quiver as well as spread, and so on.

Obviously, amplification and self-compensation phenomena associated with reflection fields are appropriate to use with any turbulent flow effect. What is discussed here is simply one very small part. A good number of problems still have not been explored. Experimental work is also very limited at the present time. In order to fully understand the characteristics of turbulent flow effects in reflection fields, it is still necessary to carry out large amounts of theoretical and experimental research work.

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ABSTRACT

This article discusses intensity fluctuations when laser light propagates in folded light paths as well as the properties of such turbulence effects as beam spread, spot quiver, path length fluctuations, and so on. Theoretical results clearly show that, when use is made of different reflectors--compared to direct light paths--one has the existence of amplification phenomena or self-compensation phenomena. This article also analyzes the mechanisms associated with the production of these phenomena.